

SIGGRAPH 2001 Fundamentals Seminar

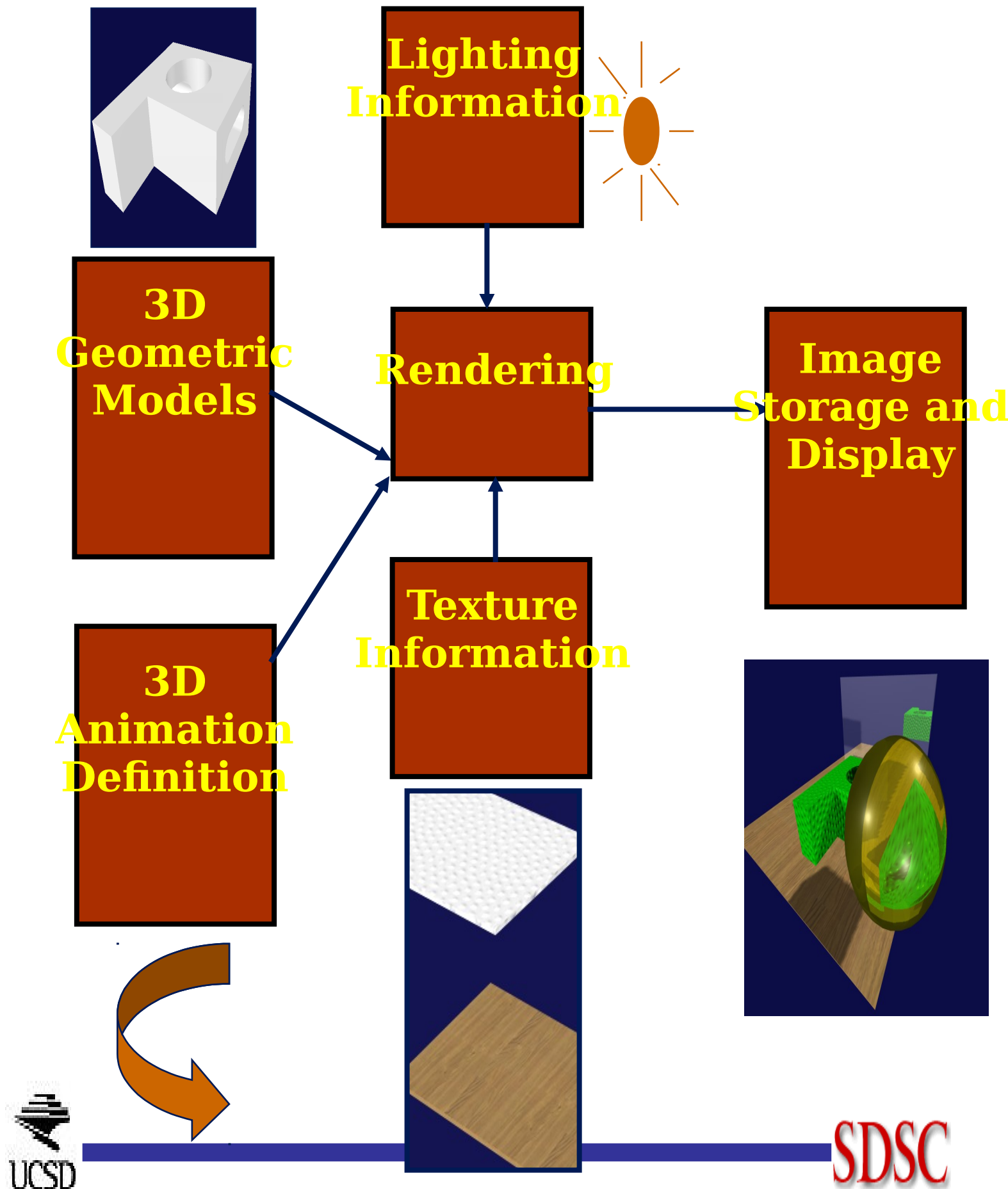
Computer Graphics Hardware

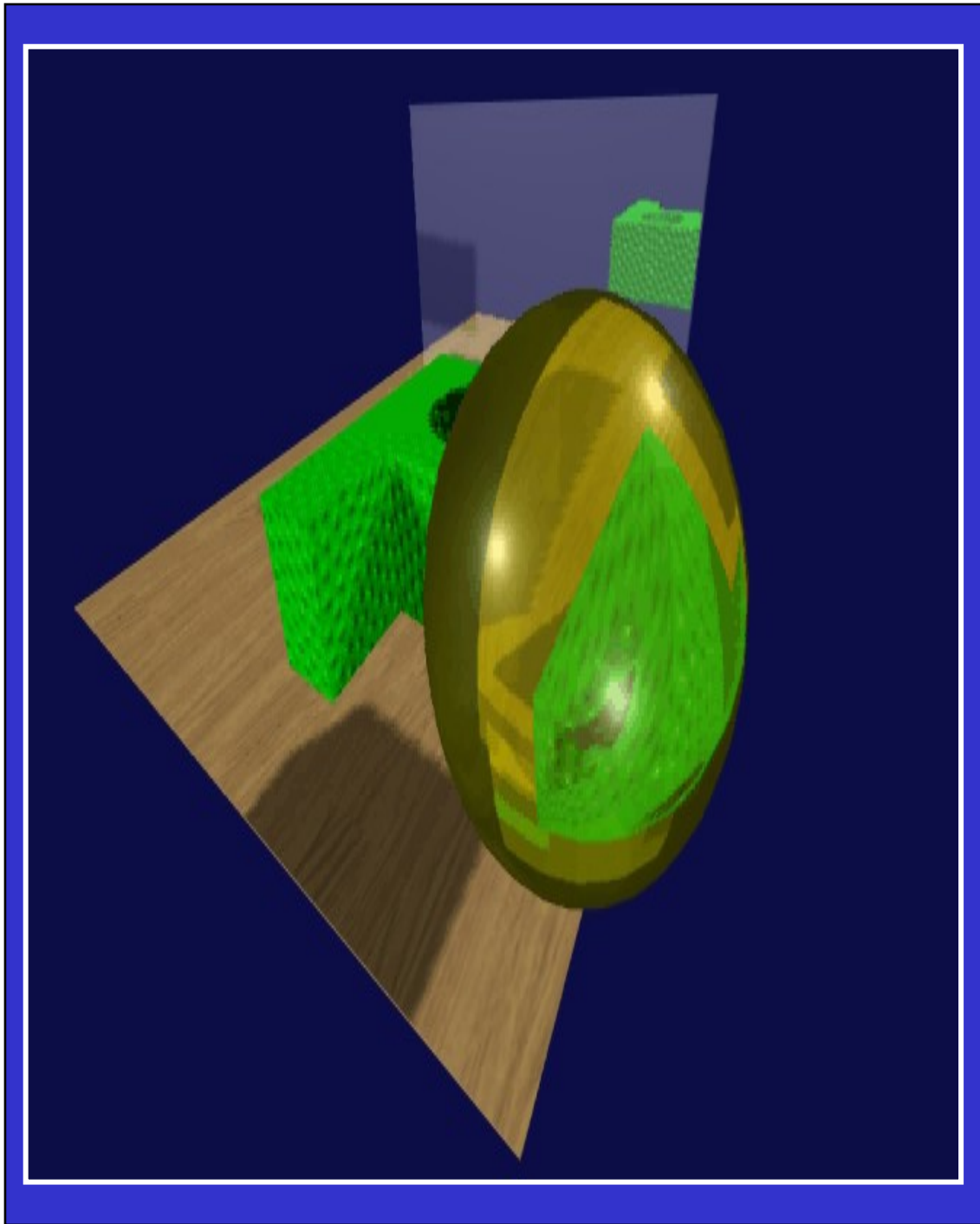
Mike Bailey

**San Diego Supercomputer Center
University of California San Diego**

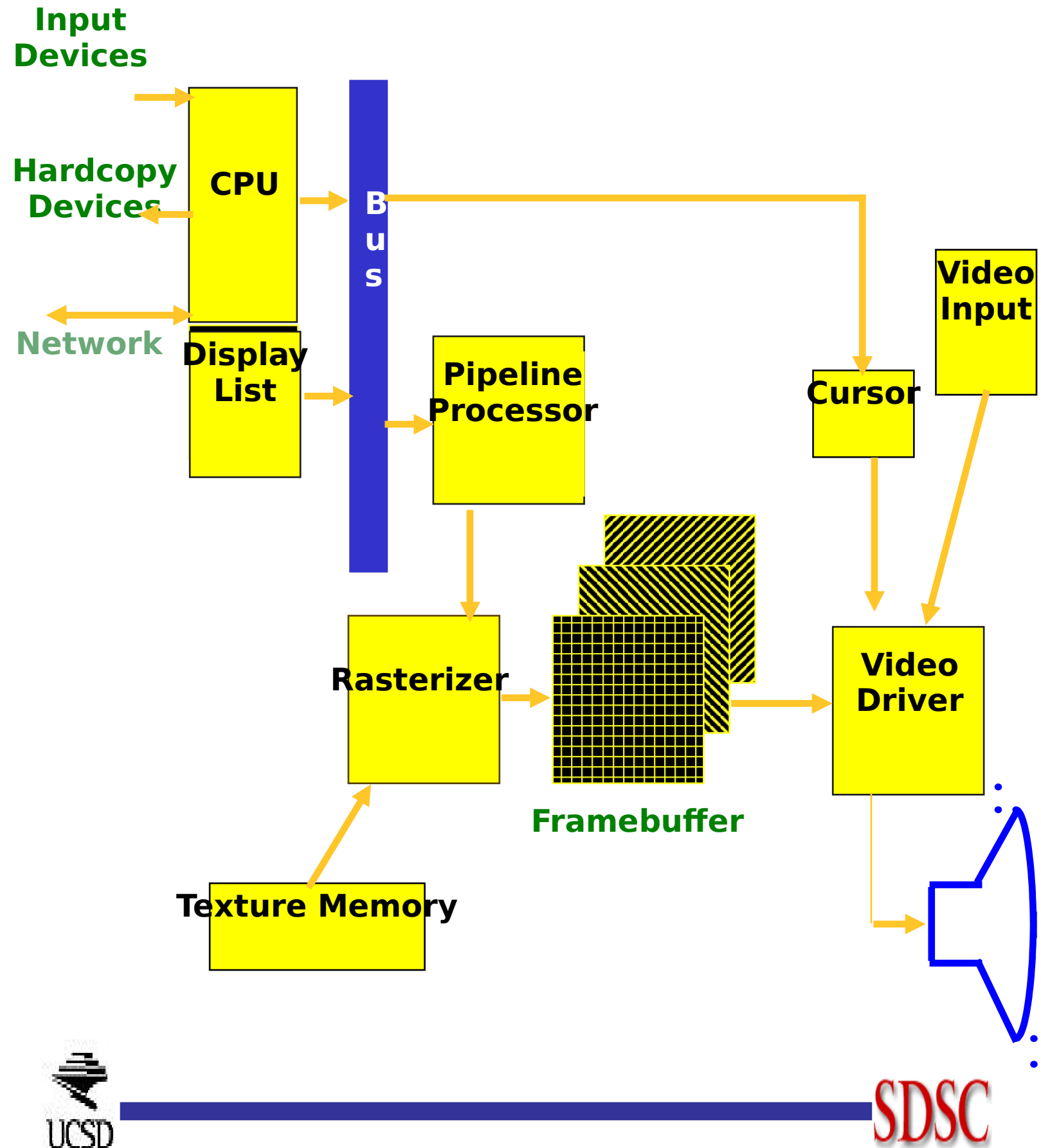
`mjb@sdsc.edu`

The Generic Graphics Process

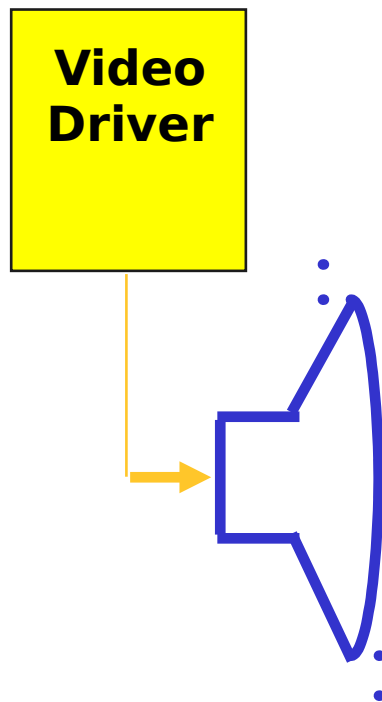




Generic Computer Graphics System

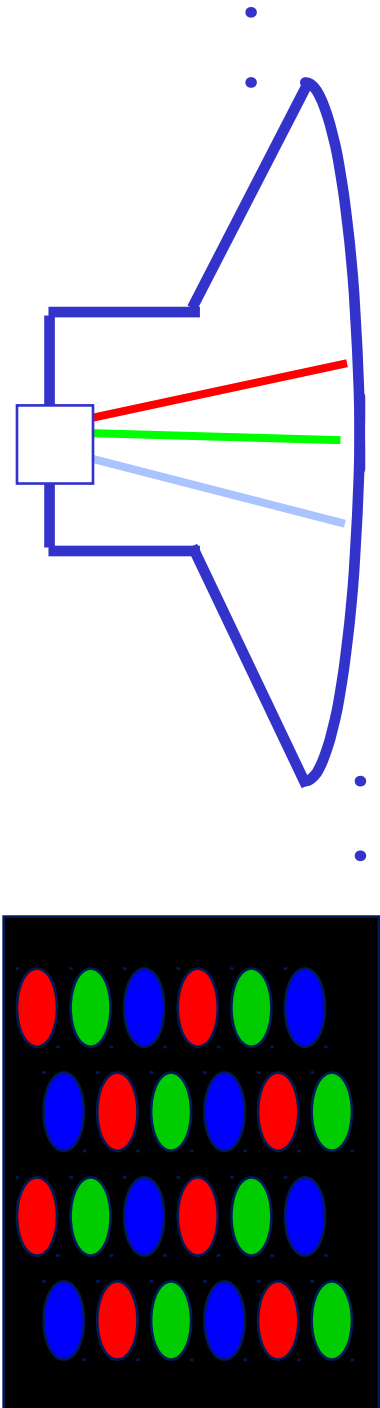


The Computer Graphics Monitor



Displaying Color on a Computer Graphics Monitor

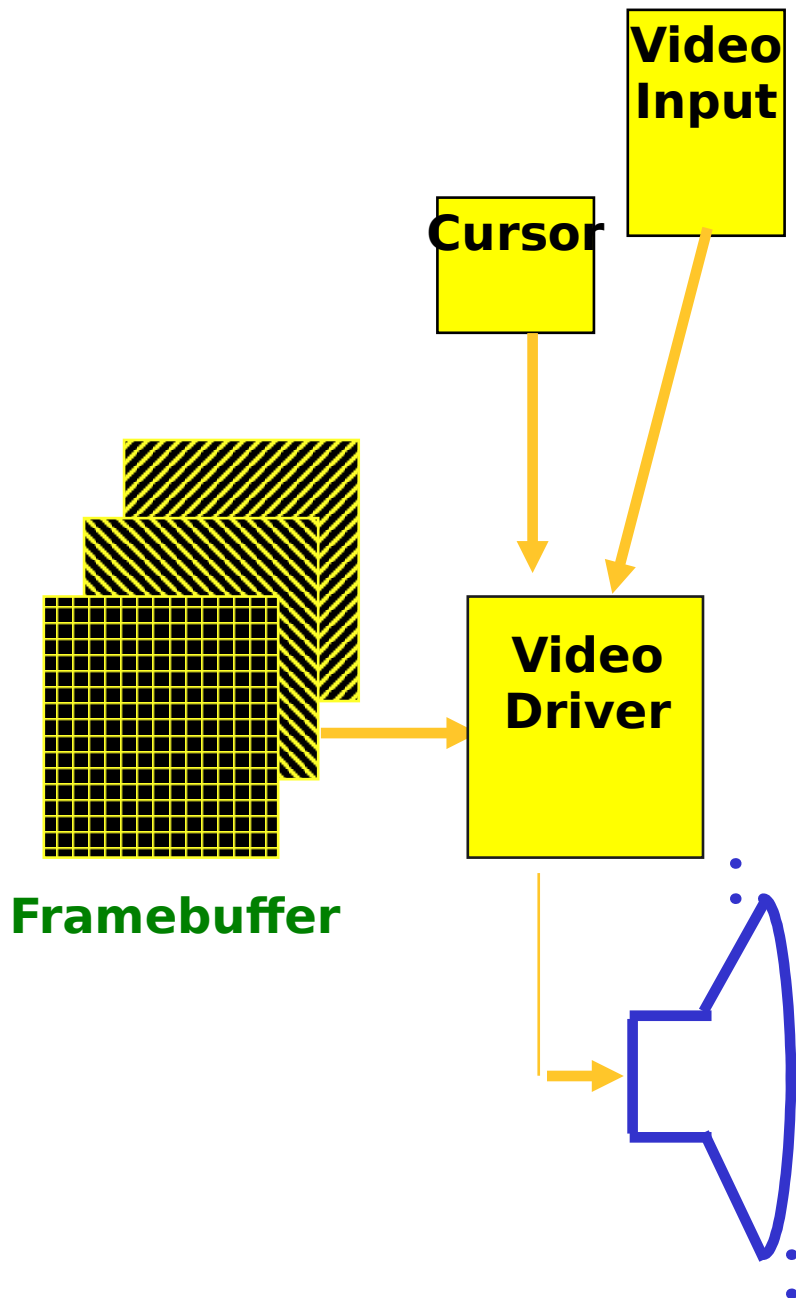
- **3 color guns**
- **Red-green-blue phosphors**
- **Gun voltage \approx color brightness**



Display Resolution

- ***Pixel* resolutions (640x480 - 1600x1024 are common)**
- **Screen size (13", 16", 19", 21" are common)**
- **Human acuity: 1 arc-minute is achieved by viewing a 19" monitor with 1280x1024 resolution from a distance of ~40 inches**
- **FYI: HDTV is talking about resolutions in the 2048x1152 range**

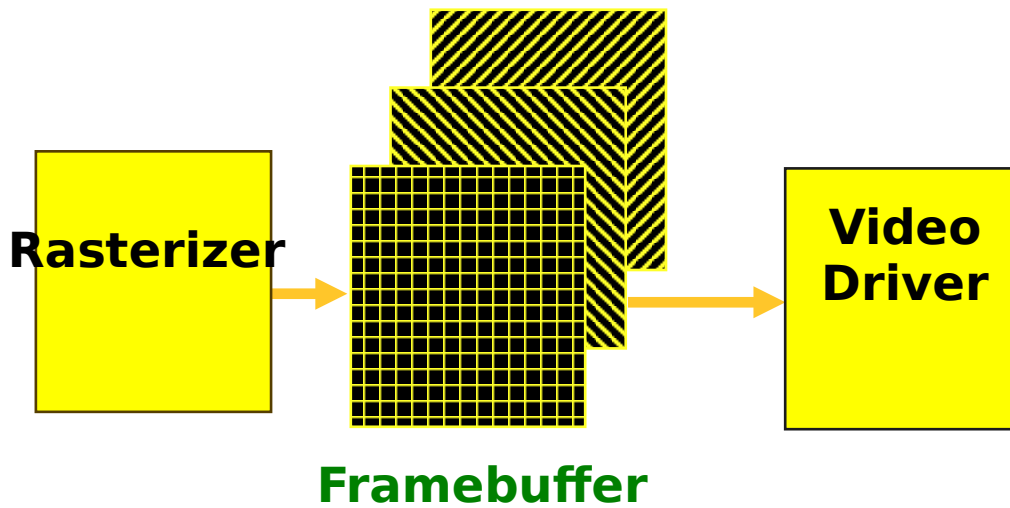
The Video Driver



The Video Driver

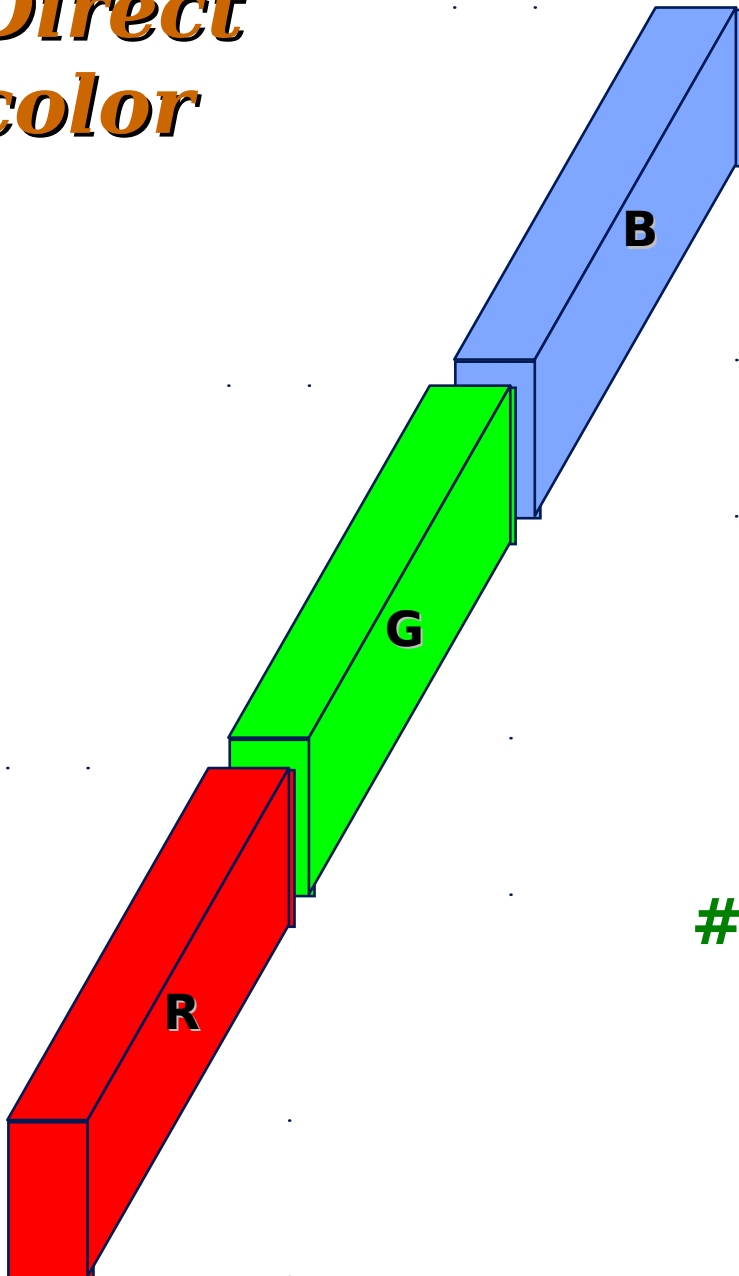
- **N *refreshes*/second** (N is usually between 40 and 80)
- **Framebuffer contains the R,G,B that defines the color at each pixel**
- **Cursor**
 - **Appearance is stored near the video driver**
in a “mini-framebuffer”
 - **x,y is given by the CPU**
- **Video input**

The Framebuffer



The Framebuffer

- Direct color*



Bits/pixel total colors:

12

$2^{12} =$

18

$2^{18} = 256$

24

$2^{24} = 16,777,216$

Bits/color #shades per color

4

$2^4 = 16$

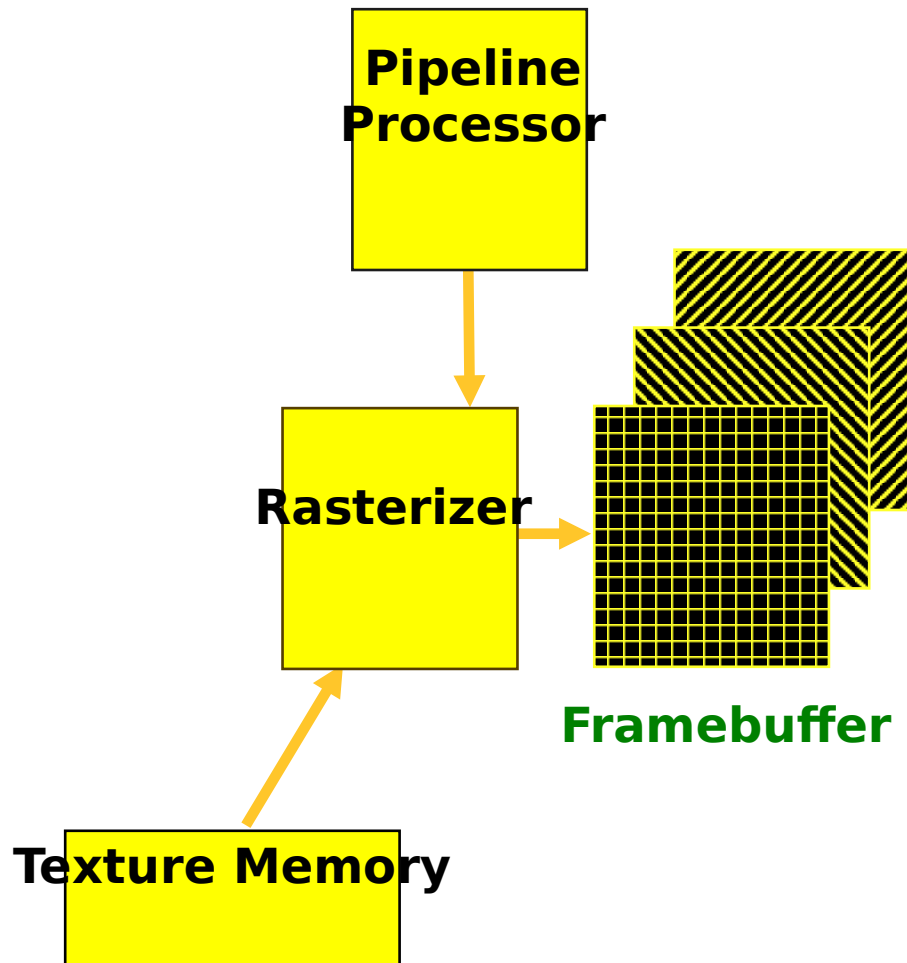
6

$2^6 = 64$

8

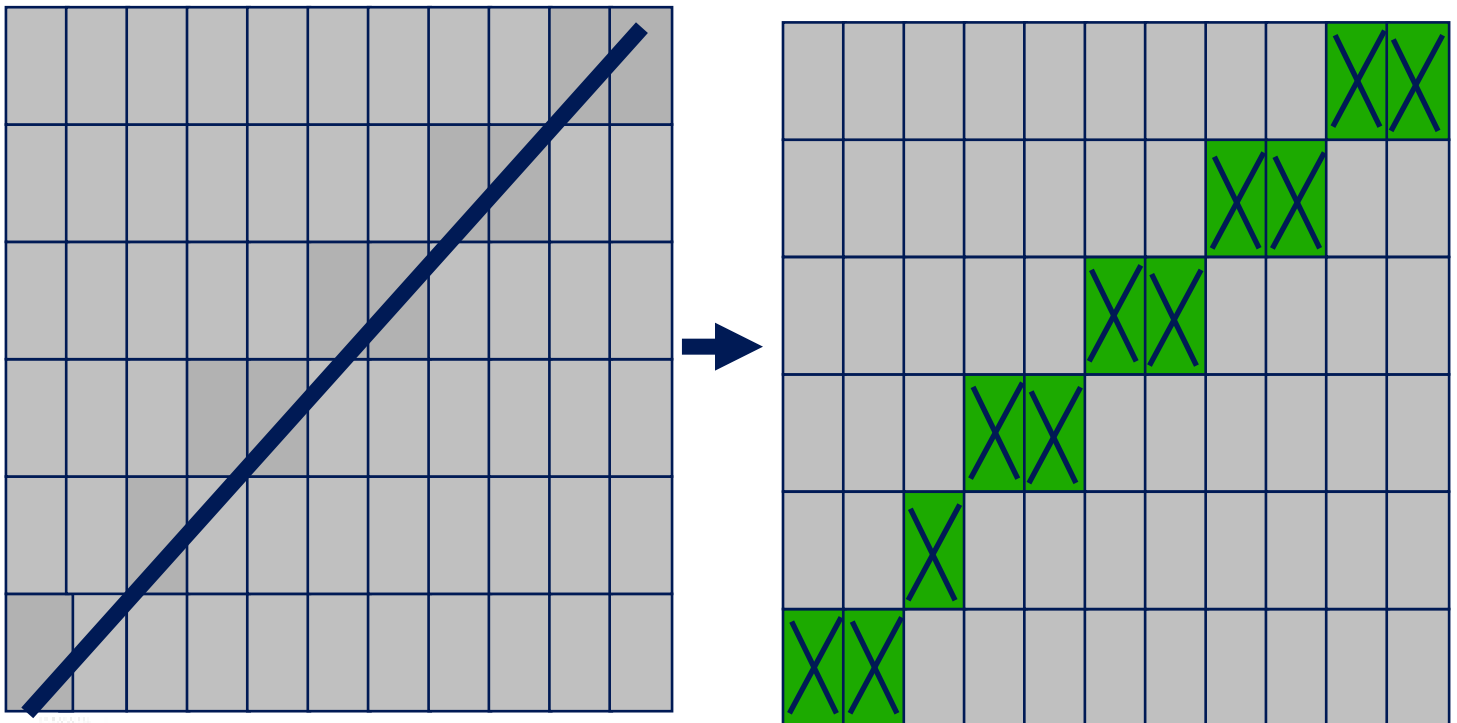
$2^8 = 256$

The Rasterizer



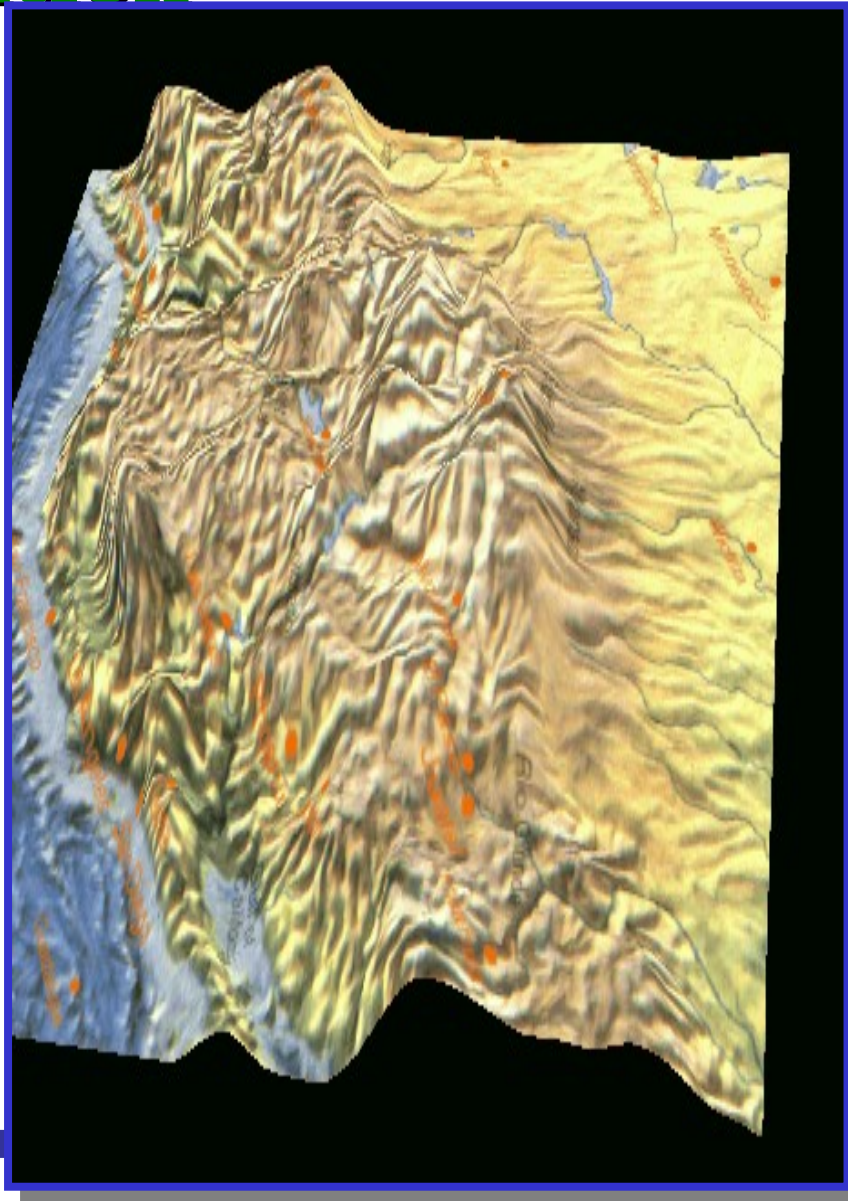
Rasterization

- **Turn screen space vertex coordinates into pixels that make up lines and polygons**
- **A great place for custom electronics**



Texture Mapping

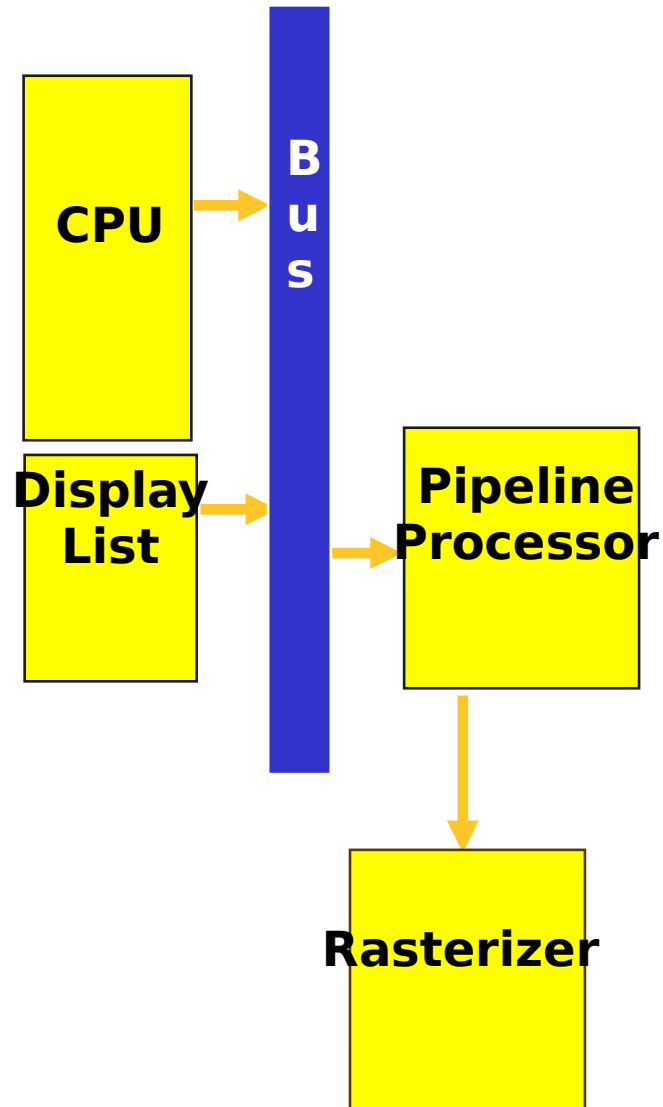
- **“Stretch” an image onto a piece of geometry**
- **Image can be generated by a program or scanned in**
- **Very useful for realistic scene generation**



Pipeline Processor

- **Coordinates enter in world (application) coordinate space**
- **Coordinates leave in screen (pixel) coordinate space**
- **Another great place for custom electronics**

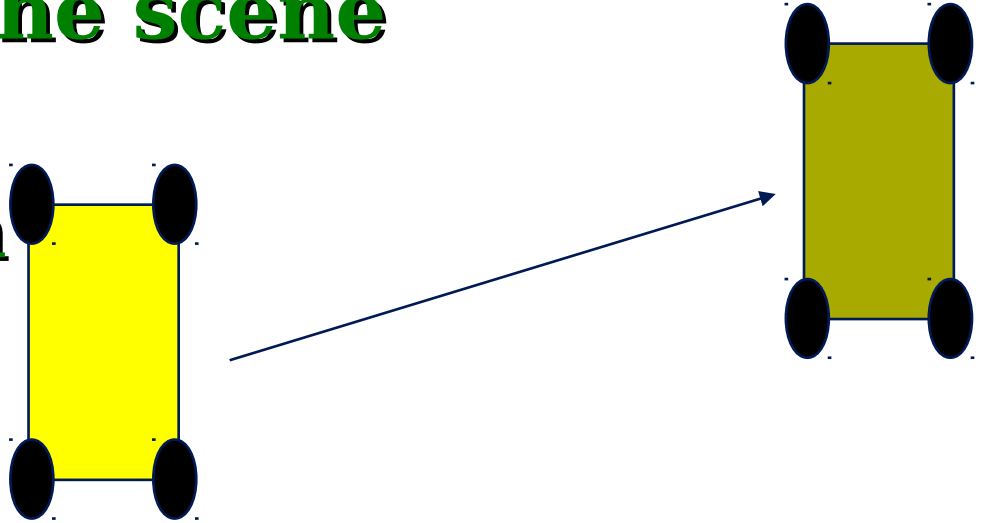
The Pipeline Processor



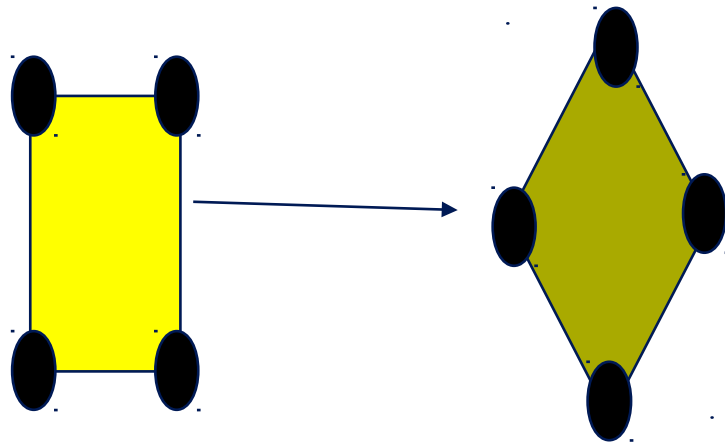
Pipeline Processor: Transformation

- **Used to correctly place objects in the scene**

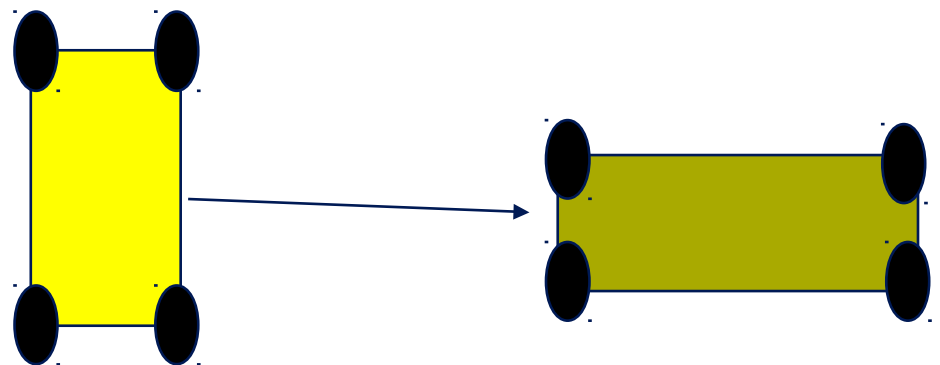
- **Translation**



- **Rotation**



- **Scaling**

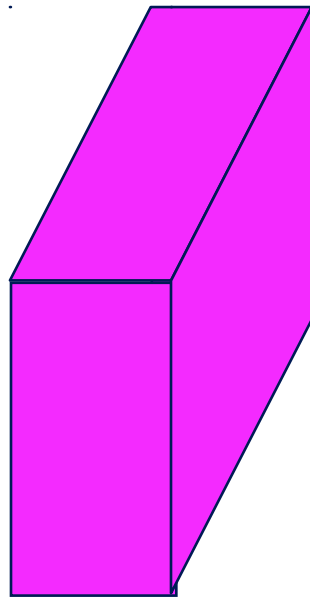


Pipeline Processor: Projection

- **Turn 3D coordinates into 2D**

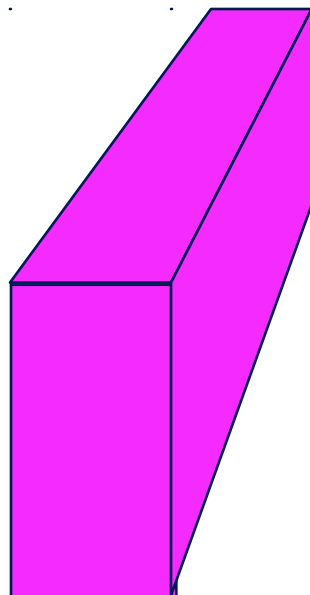
Parallel projection

Parallel lines remain parallel

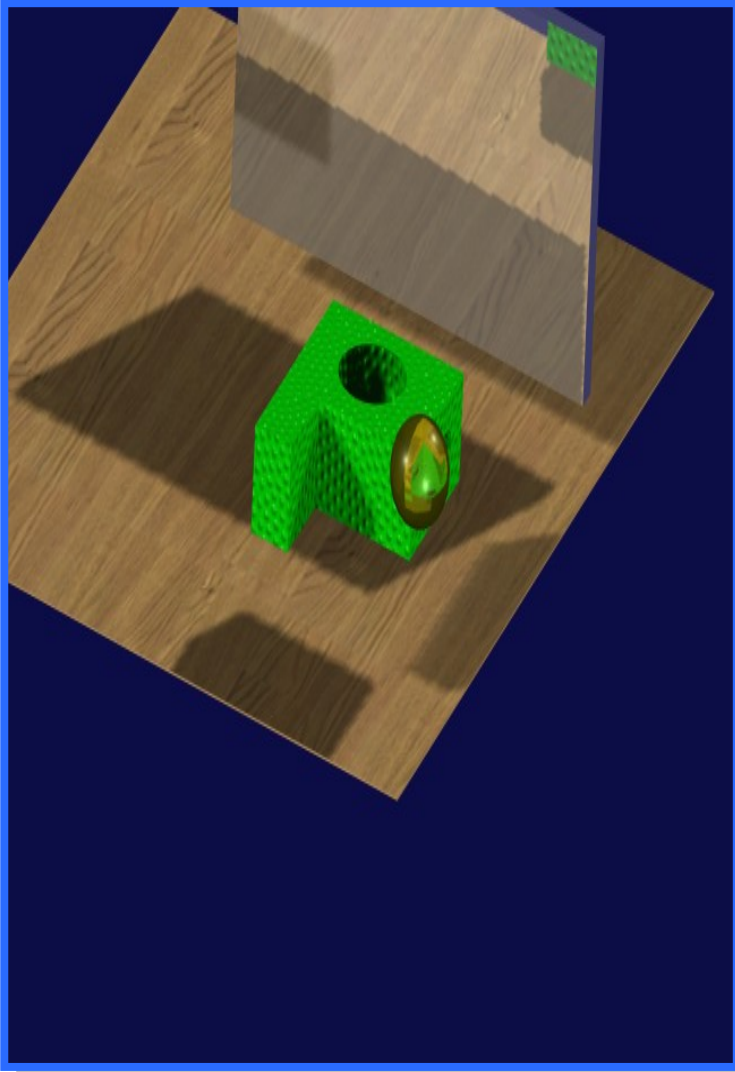


Perspective projection

Some parallel lines appear to converge

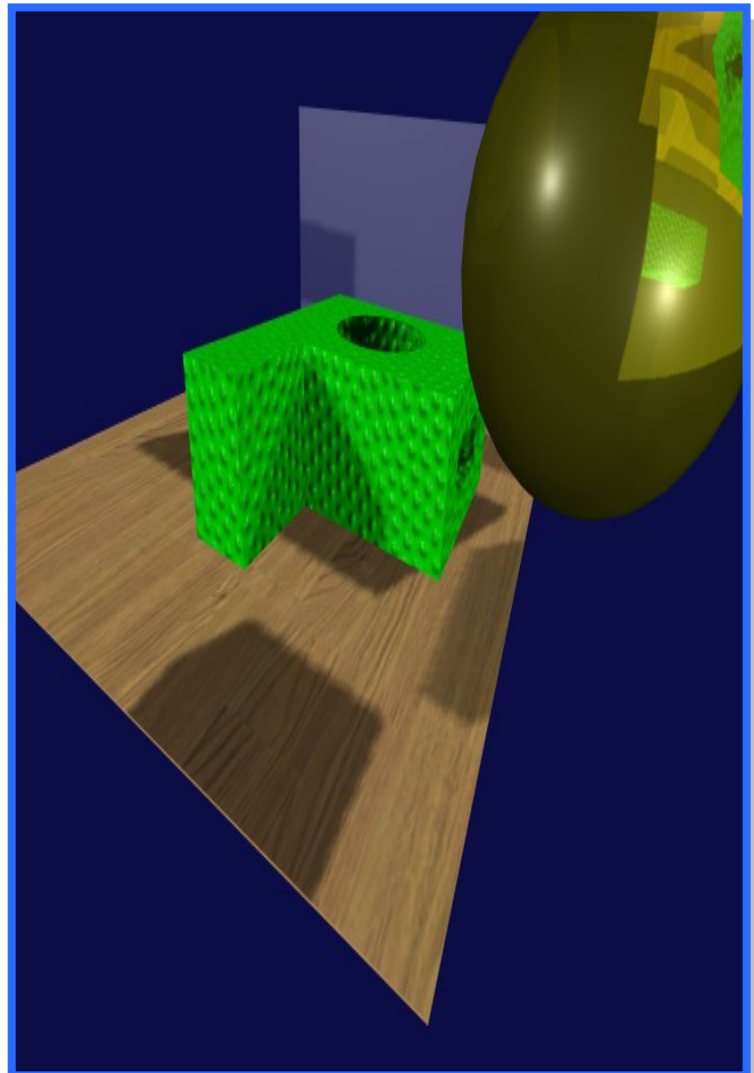


Pipeline Processor: Projection

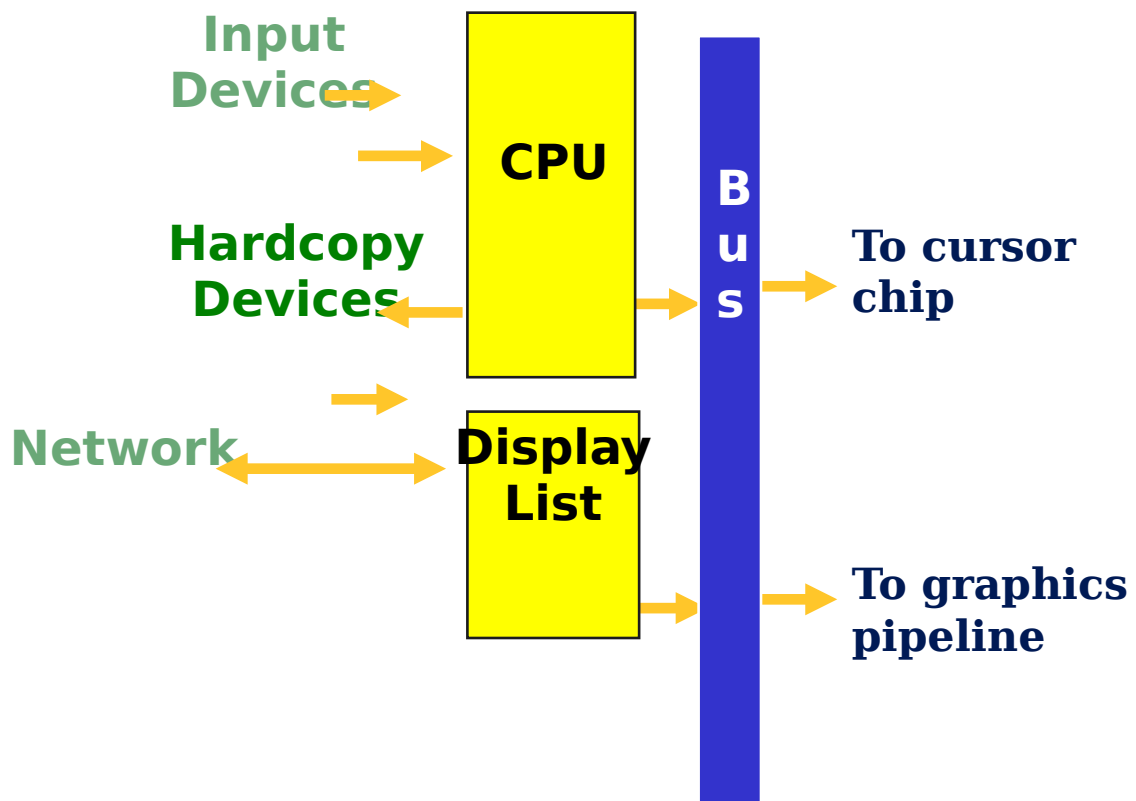


Parallel

Perspective



The CPU



Input Devices: General Categories

- **Text input**
- **Choice input**
- **Value input**
- **Coordinate input**
 - **2D coordinates**
 - **3D coordinates**



2D Coordinate Input

- **Mouse**
- **Joystick**
- **Trackball**
- **Digitizing pen**
- **Touchpad**
- **Touchscreen**

3D Coordinate Input

- **3D joystick**
- **Spaceball**
- **Linkage**
- **3D Trackers**
- **Glove**



Graphics Hardcopy Devices

- **Color paper plotters**
- **Film recorders**
- **Video**
- **Solid**

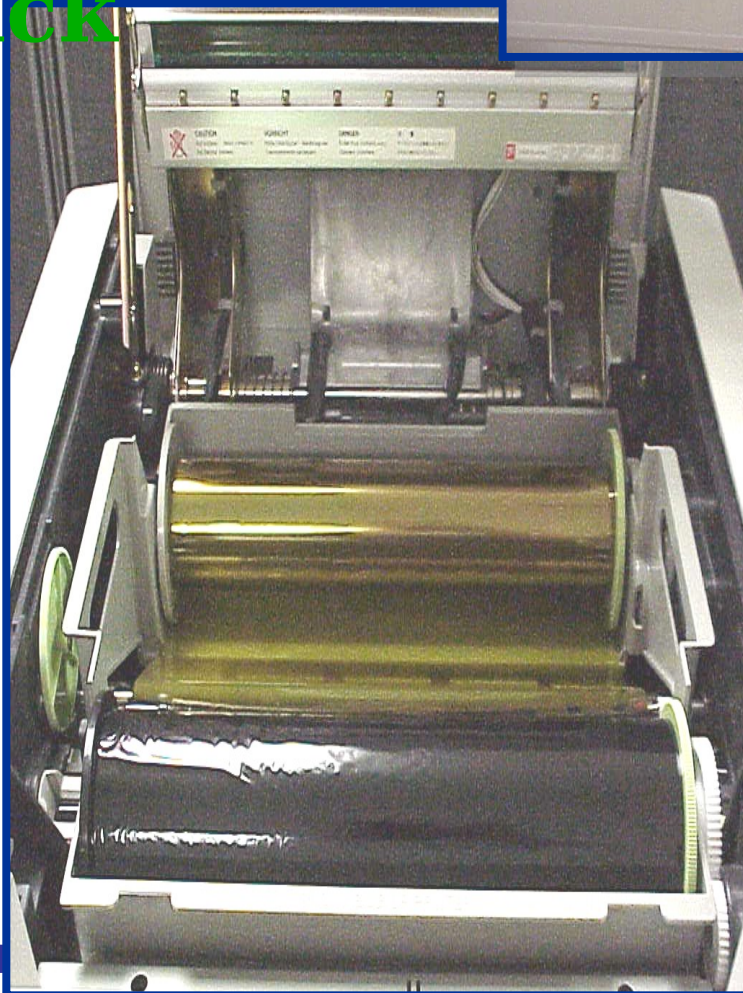
Color Paper Plotting

- Uses *subtractive colors*
- Cyan, magenta, yellow, black

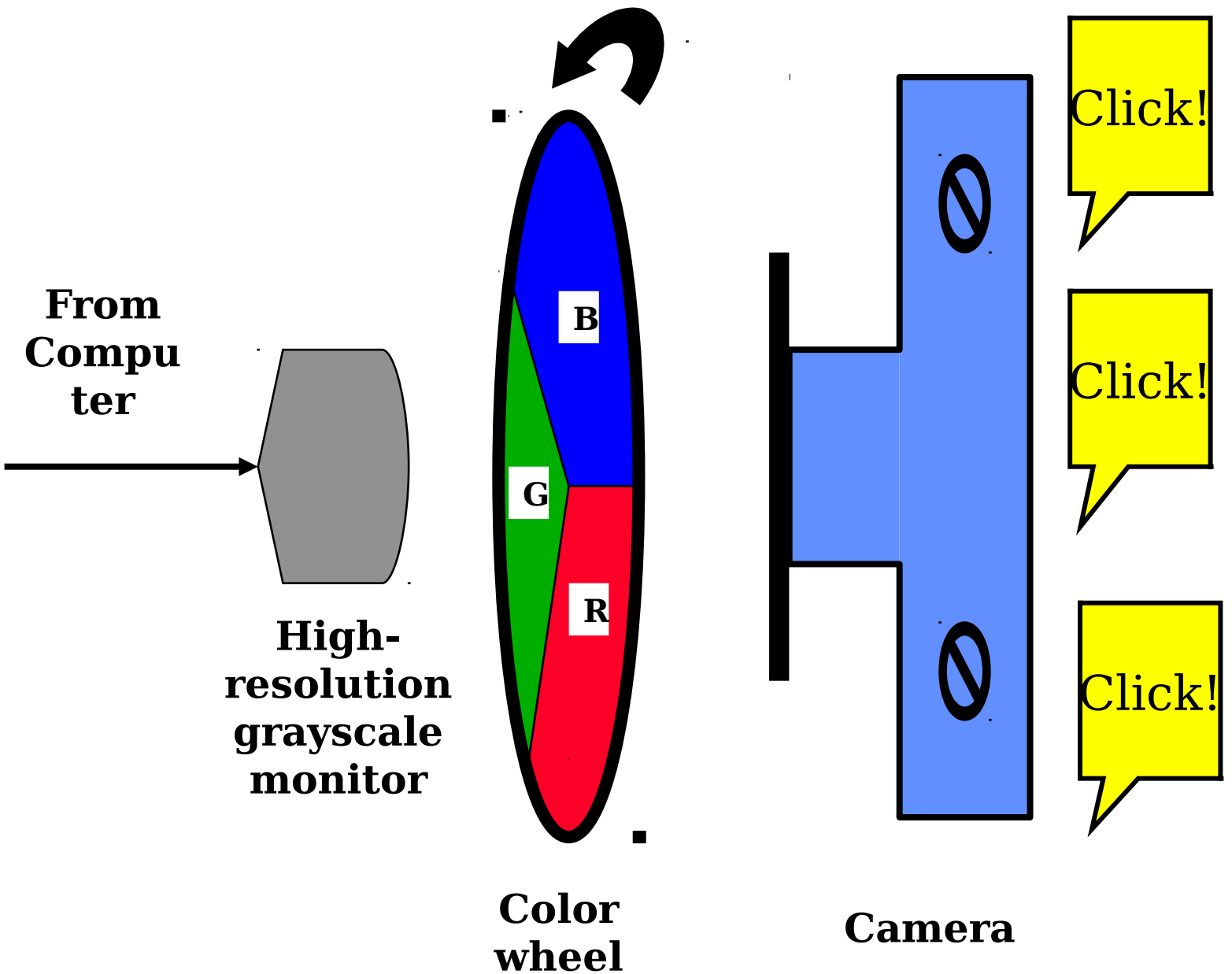


Toner

Sheets



Digital Film Recording



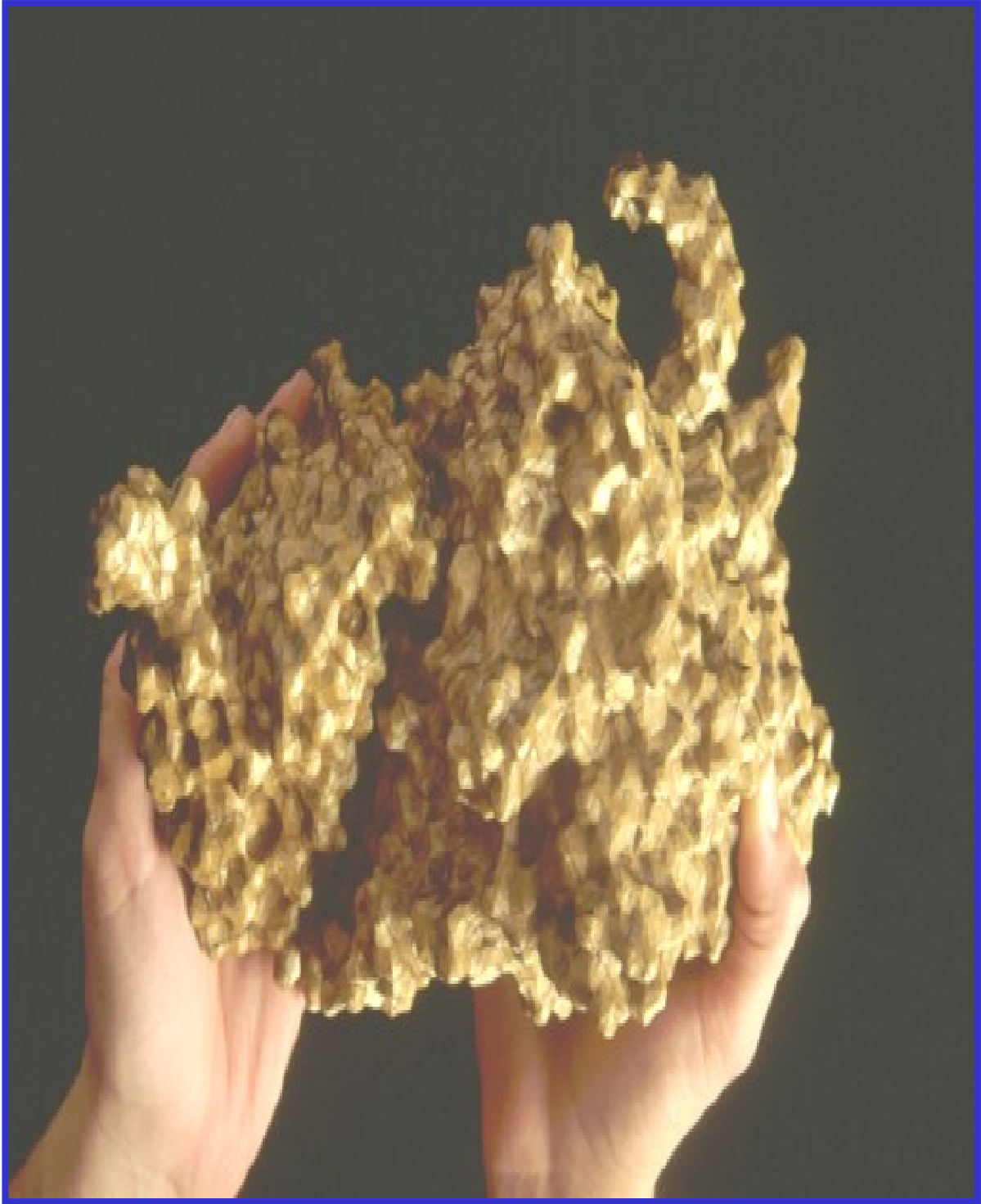
The Limitations of using NTSC Video

- **Cannot display saturated colors well**
- **Expect an effective resolution of (at best)
~640x480**
- **Do not use single-pixel thick lines**
- **Stay away from the edges of the screen**
- **Some colors have better video resolution than others**

NTSC Cycles of Encoding per Scanline

What:	Cycles/Scanline
Intensity	267
Orange-Blue	96
Purple-Green	35

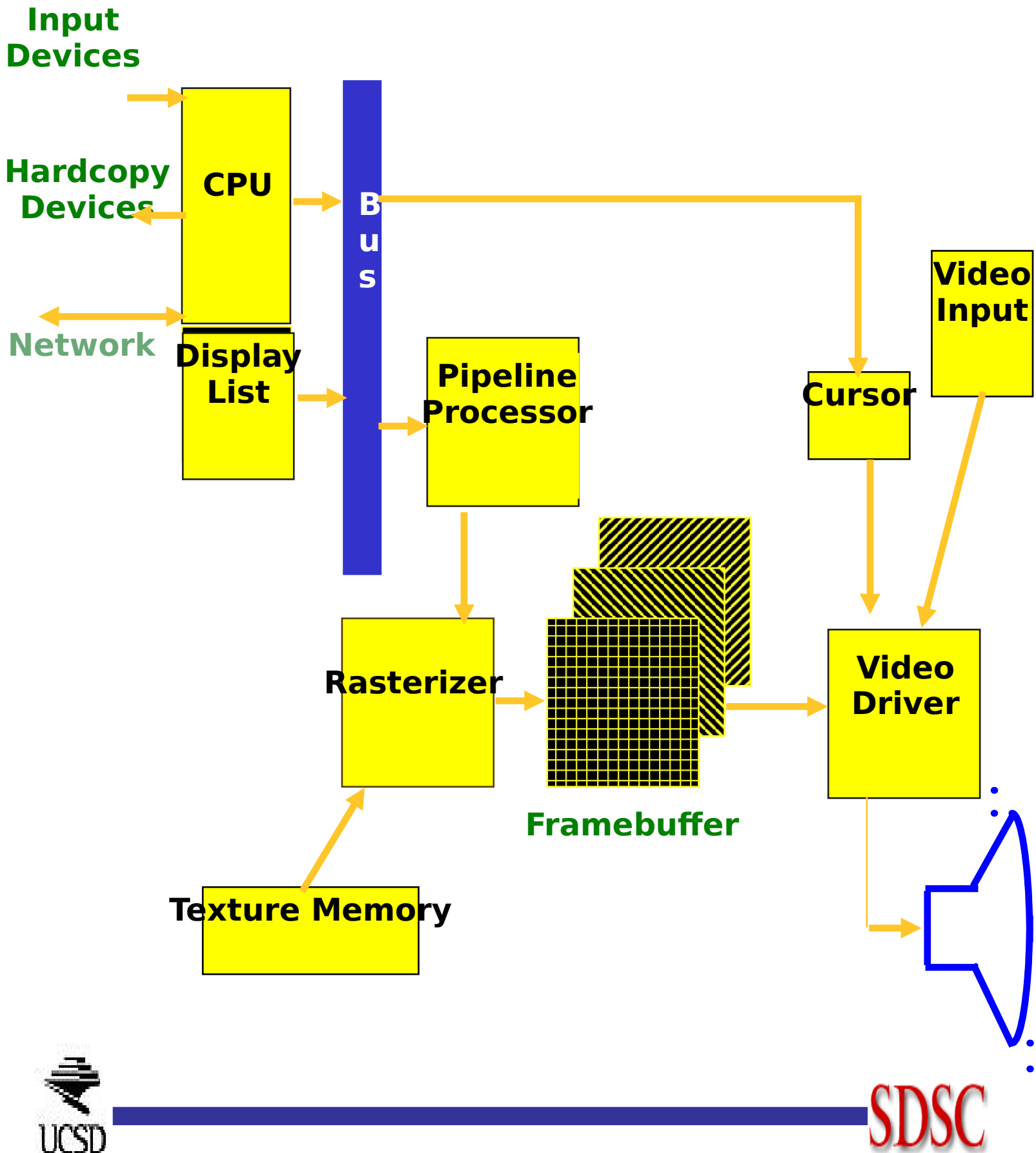
Solid Hardcopy





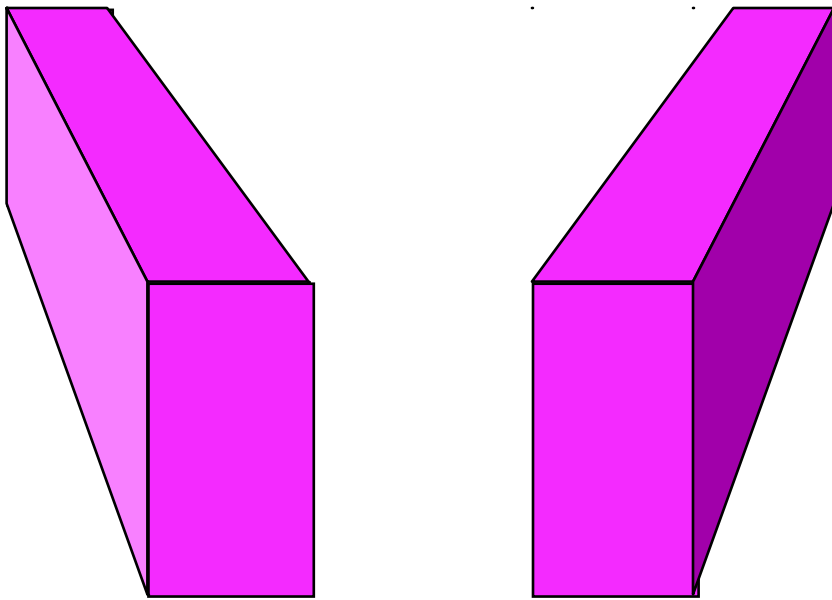


All Together, Now!

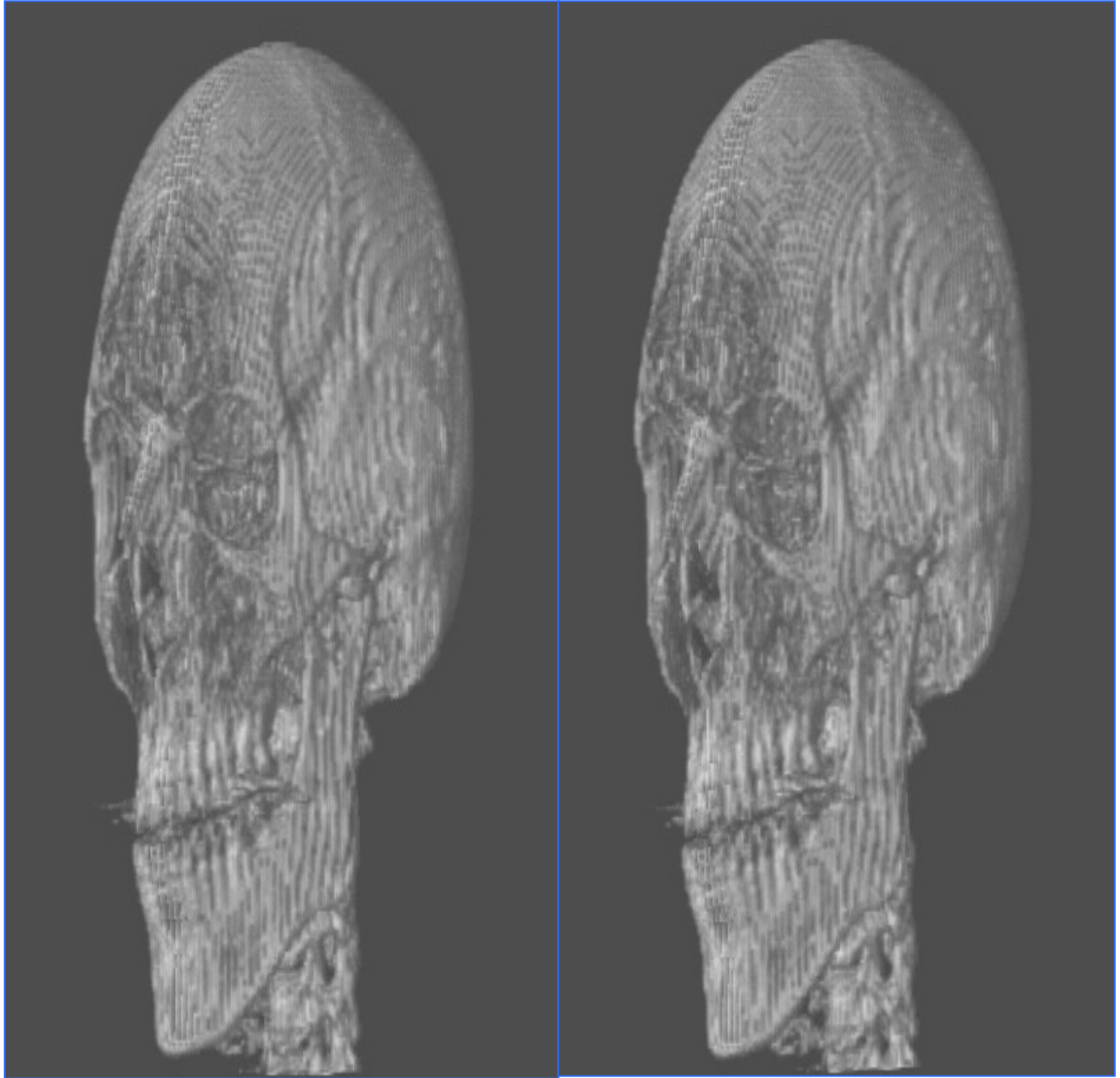


Stereographics

- **Simultaneously display both left and right eye views**



Stereographics



Left Eye View

Right Eye View

**If You are
Interested in
Learning More:**

**Hardware will be
discussed in more
detail in the
*Introduction to
Computer Graphics*
course on
Monday, 11:15 -
12:00**

**If You are
Interested in
Learning More:**

**Physical model
hardcopy will be
discussed in more
detail in the
*3D Hardcopy:
Converting Virtual
Reality to Physical
Models*
course on Tuesday
morning**

**If You are
Interested in
Hardware,
Remember:**

**The Exhibition
closes
at 5:00 on
Thursday !!**

***Have fun this
week,
and Thanks for
Coming!***

Computer Graphics Hardware

**Mike
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